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Magnetic Resonance Functional Neuroimaging of the Entire Brain during Performance and Mental Rehearsal of Complex Finger Movement Tasks

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PURPOSE:

In this study, cortical regions activated during performance and mental rehearsal of complex finger movement tasks are dynamically mapped using time-course multi-slice (1 to 10 slices) blood-oxygenation-sensitive echoplanar MRI, here termed magnetic resonance functional neuroimaging (MRFN).

INTRODUCTION:

Previous work involving single-slice MRFN has demonstrated that, during sequential tapping of fingers to the thumb, (i.e. simple finger movement) the primary contralateral sensorimotor cortex shows significant signal enhancement associated with activation (1,2,3). Recently, it has been demonstrated, using three-slice MRFN, that during a task in which the subject was asked to tap out a specified finger sequence, termed "complex" finger motion, activation was observed in the contralateral primary motor and somatosensory cortices, supplementary motor area, and premotor cortex in both hemispheres(4).

The present study demonstrates whole-volume and extended time-course MRFN of regions of the brain associated with performance and mental rehearsal of complex finger motion tasks.

METHODS:

Five healthy right-handed subjects were imaged using a standard GE 1.5-T Signa magnet equipped with an inserted 30.5 cm i.d.three-axis local gradient coil. An endcapped quadrature birdcage coil was used to obtain images throughout the entire brain volume. A blipped gradient-echo EPI pulse sequence (TE=40ms, TR = 1 to 2 seconds, FOV=24cm) was used. Image resolution was 64 x 64 and slice thickness was varied between 2 mm and 10 mm. Generally, three types of dynamic imaging strategies were used. a) 3 slices of 104 sequential images per slice bo 10 slices of 100 sequential images per slice so as to interleave all the task paradigms into a single time course.

All tasks were presented in a repetitive "on-off" manner. The on-off cycle length varied from 24 seconds to 32 seconds. High contrast to noise ratio functional images were created by finding the cross-correlation of a reference vector representing the expected time-course response with the time-course response of every pixel (5).

Tasks, performed separately on the right and left hands, were simple finger movement (as a control), complex finger movement, and mental rehearsal of complex finger movement. Simple finger movement involved self-paced tapping of the fingers against the patient table. Complex finger movement involved the tapping of individual fingers in a specific sequence presented before each "on-off" cycle. Mental rehearsal of complex finger movement was performed without motion of any type.

RESULTS

During the tasks involving finger movement, significant signal enhancement was observed in the a) contralateral primary motor and somatosensory cortices. (ipsalateral regions of activation were observed during left finger movement.) b) caudate nucleus region of the basal ganglia and c) cerebellum. During complex movement, additional activation was observed in the supplementary motor area and bilaterally in both the premotor cortex and secondary somatosensory cortex (bilateral posterior parietal regions). During mental rehearsal, activation was observed in the supplementary motor area and bilaterally in premotor cortex and secondary somatosensory cortex. Also, we

occasionally observed a decrease in signal intensity in the primary motor cortices during mental rehearsal. In most studies, the pattern of cortical activation during mental rehearsal was similar between both hands, and, other than in the primary somatosensory and motor cortices, the activated cortical pattern during complex finger movement was also similar between both hands. Figure 1 illustrates one anatomical slice and corresponding superimposed function during left-hand simple, complex, and mental rehearsal of complex finger movement respectively.

CONCLUSIONS:

We are able to perform entire brain MRFN primarily because of the high sensitivity quatrature rf coil used, the intrinsically high signal to noise ratio of EPI, and the ability to obtain high Bo homogenity over a large volume at 1.5T. A comparison between regions activated during simple complex, and mental rehearsal of complex finger movement is made. The results are in general agreement with previous non-MRI techniques of assessing the functionality of cortical regions in the human brain.

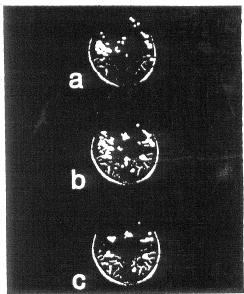


Figure 1: Finger movement on the left hand. Anatomics image with function superimposed. White = signal increase Black = signal decrease. Threshold: $p = 1.2 \times 10^{-8}$ a. Simple finger movement. b. Complex finger movement c. Mental rehearsal of complex finger movement.

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